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COASTAL WIND ENERGY AND THE UNITED STATES: AN OVERVIEW

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SUMMARY
Moving wind forward as an alternative energy source for the United States requires collaboration between the scientific community, state and national policymakers, and entrepreneurs. This paper considers some of the many issues confronting the U.S. in developing an offshore wind energy policy. Wind farms are proposed offshore of Massachusetts, New York, and North Carolina. Offshore wind turbines are used widely in Northern Europe and many inland states have well-established wind energy programs. Much of their experience can be applied to coastal projects. Problems are site-specific and controversies ever present. Underlying geology, wind direction and intensity, and oceanographic conditions vary widely. Tourists and locals may dislike the sight of wind towers in their estuaries and against their sunsets. Crucial habitats for migratory birds, marine mammals, and commercial fish may be impacted, yet research on possible environmental costs is sparse. Wind entrepreneurs must navigate multiple jurisdictions and find little government bureaucracy in place either to facilitate or regulate their activities. Agency responsibilities overlap, but disputes over jurisdiction need to be resolved quickly. Continually improving technologies will make more and more sites suitable. The National Oceanographic and Atmospheric Administration (NOAA) is well positioned to take a leading role because of its stewardship mission, its scientific research funding and collaboration with other agencies on earth observation systems.

THE EUROPEAN EXPERIENCE
Europe is at the forefront of a potential offshore wind frontier boom. Over 85% of the global wind market is supplied by European manufacturers and future potential is huge. 75% of overall global wind power capacity is installed in Europe, largely achieved through the efforts of only three countries—Germany, Spain and Denmark. (Wind Force 12 2004).

European barriers preventing wind power from reaching its full potential are similar to those of other renewable energy technologies. Pricing structures in traditional energy markets do not reflect the full costs to society of production. Wind power is getting increasingly cheap, but still needs special provisions. Overcapacity in the electricity market means that it is still cheaper to burn more coal or gas in an existing power plant than to finance and build a new wind power plant. The effect is that even where wind energy is competitive with new coal or gas fired power plants, investments will not be made.

Public and political support throughout the European Union (EU) has driven the rapid success of wind power. None of the EU member states want to increase dependence on external energy supplies. In November 2001 a European Union Directive promoting renewable energy sources was adopted. It calls for the Community to double its share of renewable power by 2010 (Svendson 2003).

WIND ENERGY IN THE US

The United States possesses large, untapped wind energy potential. Wind energy has not been developed anywhere along the 95,000 miles of U.S. coastline. Land-based wind energy projects have been developed and are typically located on mountain passes or flat, broad plains where strong winds blow consistently. Coastal wind energy is becoming more feasible as our abilities to predict wind speed, variability, and energy potential improve.

The best site for coastal wind energy is in the vicinity of Cape Cod and Nantucket Island where wind power may attain class 6. Massachusetts offers financial assistance to projects focusing on wind energy, providing approximately $150 million over a five-period and continuing to fund $20 million per year for an undefined period beyond 2002. The nation's first offshore wind farm has been proposed by Cape Wind Associates on a shallow bank called Horseshoe Shoals in Nantucket Sound, Massachusetts. 130 wind turbines located one-third to a half a mile apart over an area of 28 square miles could generate enough electricity to power around 250,000 homes (The Boston Foundation 2002). But, each turbine would be anchored to the seabed and visible from shore.

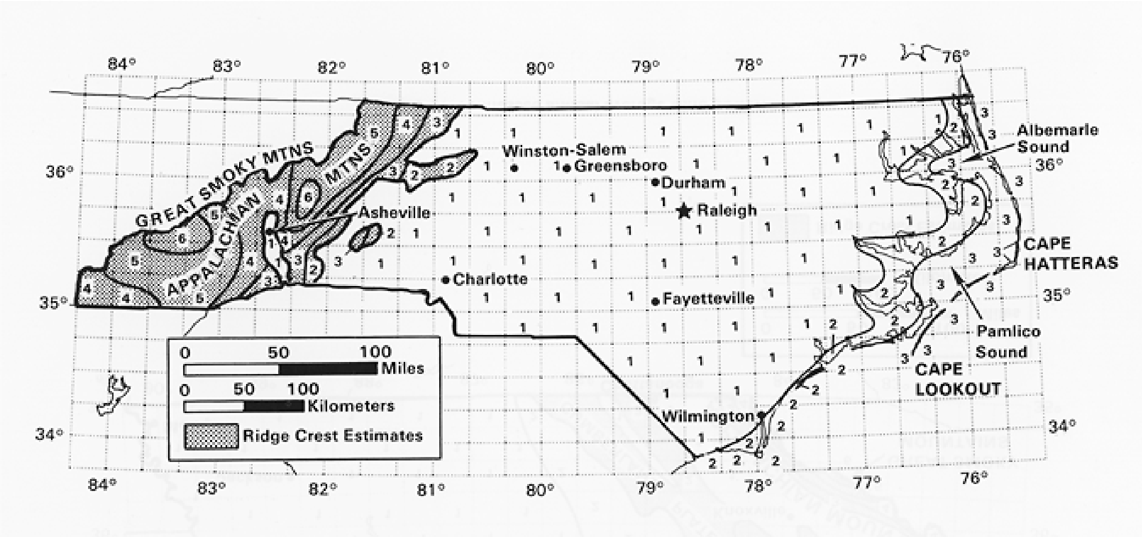
GEOPHYSICAL PARAMETERS

Any plan for developing wind energy must consider wind power class. Classes range from one through seven, with increasing numbers reflecting increases in average annual wind velocities. Wind power class 3 is considered the minimum for economic production of wind energy. Windiness varies both regionally and over time. In most parts of the United States, winds are stronger in winter and spring and average wind speed may change from year to year.

The amount of electricity produced by a turbine depends upon variable wind velocity. The power contained in the wind increases very rapidly with wind speed; if the speed doubles, the power increases by a factor of eight. But, below a minimum wind speed, a turbine does not operate. Above a certain speed the output of a turbine levels off or begins to decline. In very high winds the turbine may need to be shut down to prevent damage. Wind power density also depends on air density. Greater power can be achieved from identical wind speeds at sea level where the air is denser. Colder temperatures favor higher air densities and greater wind power production.

COASTAL NORTH CAROLINA CASE STUDY

Only a portion of northeastern North Carolina receives sufficient average annual wind speeds (class 3) to make a coastal wind energy program economical (see figure below). This area extends from Cape Lookout north to the Virginia line and includes both the open waters of Pamlico and Albemarle Sounds and the offshore waters of the continental shelf. Prevailing winds are from the southwest, but strong northeast winds also are common.



North Carolina Annual Average Wind Power
http://rredc.nrel.gov

The open sounds of northeastern North Carolina have several characteristics conducive to wind energy development. They are shallow, have relatively stable substrate in non-channel areas, and do not receive a high degree of wave energy compared to the open ocean. Northeast and southwest fetches exceed 30 miles in central Pamlico Sound making this area particularly suitable for wind energy production.

The offshore environment between Cape Lookout and the Virginia line is highly dynamic and much less conducive to the production of wind energy than the relatively protected open sound environment. Wave energy and currents are high during much of the year and are extreme during hurricanes and northeasters, threatening turbine structures. The upper substrate is commonly unstable and mobile. Although turbine structures could be constructed and operated that could withstand this environment, the cost would likely outweigh the economic benefit in a marginal wind power class 3 setting.

ENVIRONMENTAL ISSUES
Important ecological impacts should be considered when evaluating an offshore site for wind energy production (Hiscock et al. 2002). They include changes in hydrography, coastal processes, and benthic communities, the possible displacement of marine mammals, birds, and fish from preferred habitats and migration routes, effects of electromagnetic fields on the activities of sharks and rays, and the loss of nursery areas or important intertidal sites where cables come ashore.

WIND ENERGY ECONOMICS
Wind energy has become a feasible cost-effective alternative to traditional fossil-fuel burning and nuclear power plants because of technological advances in the 1980s and

1990s and public interest in renewable energy sources. Wind power generates electricity with no toxic emissions, no fuel to mine, transport or store, no water requirements, and zero waste. Initial capital and financing costs, however, are high, between 75 and 90 percent of the total for onshore projects (BWEA 2004). New power plants must be built and connected to existing grids. Land, onshore or offshore, must be purchased or leased.

Few market incentives exist to promote wind energy as a natural resource, but improving wind turbine technology allows for fewer, larger, and more efficient turbines. Financing costs should drop further as wind energy successes build in Europe and investor confidence improves. Competition remains stiff, however. Most utilities in the United States use coal-fired power plants that are paid for and produce relatively cheap electricity. External costs, including environmental damage from mining, carbon dioxide pollution and global warming, and human health impacts, still do not figure in cost accounting or corporate balance sheets.

CURRENT POLICIES FALL SHORT

Lack of a comprehensive regulatory structure slows coastal wind energy development. Entrepreneurs must chart a course between state and federal waters. States own title to submerged lands and natural resources out three miles, but the federal government has jurisdiction and power of disposition over submerged lands beyond the three-mile boundary. The federal government also reserves the right to prevent obstructions to navigation in state waters. The situation with Cape Cod Wind in Massachusetts demonstrates the problems. In the absence of comprehensive coastal wind energy regulations, the U.S. Army Corps of Engineers (ACE) has taken control over the project under its general authority to issue permits for structures in navigable waters and on the outer continental shelf. The Corps is acting as the lead federal agency under the National Environmental Policy Act (NEPA) and is developing an Environmental Impact Statement. A Corps permit, however, does not confer property rights or exclusive privileges, raising potential conflicts between offshore wind companies and other competing users, like fishermen (Wilhelm 2003).

Individual agency responsibilities too are confusing and appear to overlap. The National Oceanographic and Atmospheric Administration (NOAA) is the lead agency charged with administering the Coastal Zone Management Act (CZMA) and the Marine Mammal Protection Act. NOAA approves state coastal management plans, manages marine fisheries, and monitors weather conditions along the coast and in the ocean. But, the Minerals Management Service within the Department of Interior handles oil and gas leasing of subterranean lands on the Outer Continental Shelf (OCS). The U.S. Fish and Wildlife Service reviews potential wind energy development for compliance with NEPA. The Federal Energy Regulatory Commission (FERC) licenses offshore wave and tidal energy projects under Part 1 of the Federal Power Act.

NOAA is well positioned to take a leadership role because of its stewardship mission, scientific research funding and alternative energy experience. The Ocean Thermal Energy Conversion Act established a licensing program within NOAA for facilities and plantships that would convert thermal gradients in the ocean into electricity. NOAA promulgated regulations, but withdrew them in 1996 due to lack of public interest. Oil prices then were simply to low for thermal energy to turn a profit.

CONCLUSION AND RECOMMENDATIONS

Only part of the answer to the United States' hydrocarbon addiction is blowing in the wind. European nations proved that coastal wind energy technologies can work, but the problems and environmental issues are complicated and very site specific.

Most of the US Atlantic and Gulf coasts (both inshore and offshore) are either marginal or below the wind power class considered necessary for economic wind energy production at this time. A major exception is the area around Cape Cod. Technology may improve and make more sites economically viable. The cost of coastal wind power almost certainly will compare more favorably to more traditional energy sources as infrastructure develops. Along the southern and central California coast, wind power classes are also marginal or below. The tectonic setting, steeply sloping continental shelf, and high-energy wave regime along the entire western coast may make expansion of the land-based wind energy programs a more feasible option.

Wind energy development would benefit from the information obtained by a global and fully integrated earth observation system and expansion of innovative partnerships at all levels—industry, academia, non-governmental, and international organizations. NOAA, NASA, the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy, and industry groups like the American Wind Energy Association (AWEA) all possess well researched data that could be used to establish a wind energy program.

LITERATURE CITED.

British Wind Energy Association. (2004). The Economics of Wind Energy. Retrieved October 2004 from www.bwea.com/ref/econ.html.

European Wind Energy Association. (2004). *Wind Force 12: A blueprint to achieve 12% of the world's electricity from wind power by 2020.* Retrieved November 2004 from http://WF12-2004_eng.pdf.

Hiscock, K., Tyler-Walters, H., & Jones, H. (2002). High Level Environmental Screening Study for Offshore Wind Farm Developments – Marine Habitats and Species Project. *Marine Biological Association to the Department of Trade and Industry New & Renewable Energy Programme*. W/35/00632/00/00.

Svendson, Gert Tinggaard. (2003). *The Political Economy of the European Union*.

The Boston Foundation. (2002). *Boston Indicators Report*. Retrieved in October 2004 from www.tbf.org/indicators/environment/overview.asp?id=250.

Wilhelm, Isaac. (2003). Offshore Wind Farm Sparks Debate. *TCS Bulletin*. 25(1).

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